

taken in Britain (one specimen, locality unknown) but has not been found since and requires confirmation; it lives on the hoary mullein, *V. pulverulentum*. Another Cionine, *Stereonychus fraxini* Deg., is common e.g. through Denmark, and ought to be found with us even if only rarely. Its foodplant is the common ash, the foliage of which is not known to support any British beetle and thus may receive too little attention from collectors.

Dimorphism in *Papilio* Pupae

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Before describing a recent experiment with *Papilio demodocus* Esp., I propose making some general remarks and recapitulations.

Broadly speaking the pupae of the African and Indian *Papilios*, with which I am well acquainted, both at first hand and from literature, can be divided into two groups, those which are highly procryptic in shape, and those which are not. The former, which includes the cylindrical, stick-like pupae of *Chilasa* Moore and the dried, curled leaf-like pupae with projecting subdorsal processes of *Polydorus* Swains., are usually monomorphic and brown in colour, although the pupa of *C. paradoxa* (Zinken-Sommer) is said to be green or brown 'according to the colour of the twig to which it is fastened' (Talbot, *Fauna of British India, Butterflies*, i, 2nd edit.), and that of *P. dasarada* (Moore) is said to be greenish yellow with lilacine stripes (Talbot, *loc. cit.*). On the other hand the pupae of *Troides* Hbn., *Papilio* L. and *Graphium* Scop. are not particularly procryptic and are usually dimorphic, having a green and a dark form. Possibly polymorphic would be a better term as, although the green forms are fairly constant, the dark forms vary quite considerably in shade, and *P. demoleus* L. and *P. demodocus* have a pink form as well. There are exceptions to this, for instance the highly specialised, flattened, leaf-like pupa of *P. dardanus* Brown is, as might be expected, always green. Another exception is the pupa of *Graphium pylades* (F.), which is always green, but this exhibits a certain degree of dimorphism in the presence or absence of small purplish marks above the subdorsal pale line. The invariable green coloration of the *pylades* pupa is something of a puzzle, the larvae are common on a small tree of the food-plant growing in my garden, but I have never found a pupa formed under its leaves and, as the pupa often undergoes a fairly long diapause, it seems likely that it is formed away from the food-plant, which is deciduous. Incidentally Talbot's statement that the pupa of *Troides* is sustained by separate lateral threads attached to a tubercle on each side of the pupa is incorrect. A little thought will show that this form of attachment is a physical impossibility as the tubercles do not exist

when the threads are spun. The pupa is actually supported by a girdle in the usual way, but the portion across the dorsum is not visible as it has been embedded in the cuticle by the weight of the pupa when it was newly formed and the cuticle soft.

An exact parallel occurs in the larval coloration of the choerocampine Sphingidae in general and the genus *Rhagastis* Roths. & Jord. in particular. There are species whose larva is always green, others where it is always brown, and yet others where the larva is dimorphic—either green or brown.

A point that I have never seen recorded in print is the fact that it is impossible to forecast the final colour of *Papilio* pupae in the pharate stage, in some other species—*Danaus chrysippus* (L.) (Danaiidae) with its green or pink pupa, and many species of the genus *Colotis* Hubner (Pieridae) with their green or straw-coloured pupae, for example—the final colour of the pupa is plainly discernable in the late pharate stage, but the dark colour of *Papilio* pupae does not develop until after the final larval skin has been shed and the pupa is in the process of hardening. Empty pupa shells of *chrysippus* and *Colotis* are visually indistinguishable, colourless and transparent, irrespective of the original colour of the pupa, but the colour of the empty pupa shells of *Papilio* remain distinct after the imago has emerged.

Probably the oldest explanation for this dimorphism was that it was a means to match the surroundings in which the pupa was placed and there was considerable discussion and experimentation to ascertain how the dimorphism was activated, whether, for example, the stimulus was visual through the eyes or through special colour receptors placed somewhere on the body. (Poulton, 1892).

Collecting and breeding the citrus-feeding *P. polytes* L. and *P. demoleus* in India, I found so many exceptions to this 'matching' theory that I became dissatisfied and conducted some rather crude experiments with the two species. The full-fed larvae, after passing their final evacuation, were confined in circular tins, enamelled inside in various colours, both natural and unnatural, and covered with a piece of glass, and left to pupate. The overall results, which were too small to be statistically significant, did little to confirm the 'matching' theory, but it was noticed that those larvae that slipped through their girdles and pupated at the bottom of the container produced a far higher proportion of brown pupae than those that had pupated successfully suspended by their girdles. This suggested that movement by the larva immediately prior to pupation might be a factor controlling the production of brown pupae. (Sevastopulo, 1948).

In 1956 a paper was published (Hidaka, 1956) describing experiments with the Japanese species *P. xuthus* L. and *P. protenor demetrius* Cr. It was stated that all pupae formed in a small, dark box were of the brown form and that, in July

and August, when the weather was very hot, the majority of the pupae were green. It is not altogether clear from the text that these green pupae were not formed in the small, dark boxes, but the inference is that they were not. For this reason the experiments were carried out in June, September and October. The first series of experiments consisted of tying a fine silk ligature tightly round the pharate pupa at either 7 a.m. or noon following the evening during which the larva suspended itself. The result of the 7 a.m. ligature was to produce a parti-coloured pupa, the part posterior to the ligature green and that anterior brown. When the ligature was placed at noon, all the pupae were completely brown. The second series consisted of destroying various ganglions and it was found that pharate pupae without the ganglion of the head, the suboesophageal ganglion or the prothoracic ganglion always produced green pupae, whilst those that were without the ganglion of the meso-thorax or the first abdominal somite mostly produced brown pupae. From this it was deduced that it was essential that the complex of the cervical, the suboesophageal and prothoracic ganglions to be intact during the prepupal period if a brown pupa was to be produced, and it was suggested that the brown colour was the result of a hormone produced, or controlled, by them. West (see below) refers to additional Japanese papers, but I have not seen them.

Very little else appears to have been published until fairly recently when the suggestion was put forward that the dimorphism in the pupae of *P. demodocus* might be seasonal, green pupae appearing in the rainy season and brown in the dry (Owen, 1971).

About the same time another paper appeared (Oldroyd, 1971), pointing out that chemically the difference between the empty pupa shells of green and brown pupae of *P. memnon* L., was the presence of melanin in the latter and its absence in the former.

A further paper (Clarke & Sheppard, 1972) gave details of the proportions of green to brown pupae of the American *Battus philenor* (L.) found in the wild and described experiments with large numbers of pupae of *P. polytes* bred in captivity. In *philenor* there appeared to be some relationship between the thickness of the twig on which the pupa was formed and the colour, thin twigs producing green pupae and thick ones brown. From the results of the experiments with *polytes*, it was suggested that the normal pupal colour was green and that brown pupae only appeared as the result of certain stimuli.

In the course of personal correspondence, Professor Clarke informed me of experiments carried out with *philenor* in America which suggested that the stimulus needed to produce brown pupae was roughness of the surface to which it was attached.

I, therefore, decided to work on those lines with *P. demodocus*. The apparatus was simple — glass jars of approximately 4" in height and $1\frac{3}{4}$ " in diameter were lined, either inside or out, with sandpaper, the mouth being covered either by a piece of sandpaper with a weight on it, or by a piece of glass with sandpaper above. The larvae were placed in these pupating jars immediately after they had passed their final evacuation, usually some time in the evening, and the jars were kept in a closed wooden box until pupation was completed. The results were as follows:—

	Smooth surface	Rough surface
Green pupae	11 (23·40%)	1 (1·89%)
Brown pupae	25 (53·20%)	50 (94·34%)
Pink pupae	11 (23·40%)	2 (3·77%)

There can be no doubt from these figures that the rough surface produced more brown pupae than the smooth, but is this purely the effect of the surface, or does the rough surface tend to make the pupating larva wander further before it finally settles down and spins its girdle?

The above figures have been somewhat distorted by a factor that was not appreciated until it was too late, but which does tend to support the hypothesis that the brown pupal colour results from movement. During the early part of the experiment, larvae were not very numerous and it was possible to rear each larva, often from the egg, in a separate container. Later in the experiment larvae became far too numerous for this to be possible and they were reared in batches of about twelve larvae until half way through the last instar when they were separated and transferred to individual containers. All through the experiment, either by accident or design, an occasional larva was allowed to pupate in the container in which it had fed among the leaves. During the first part of the experiment, when all larvae were being reared separately, all these pupae were green, in the latter part they were invariably brown. Similarly no green pupae appeared in either the rough or the smooth containers during the second part of the experiment. Unfortunately this was not realised until too late, otherwise the contrast between the two sets of figures would have been far greater. It is proposed to repeat the experiment using only larvae that have been reared separately.

(to be continued)

PYRONIA TITHONUS L. AB. ALBIDUS COCKERELL IN THE ISLE OF WIGHT.—I captured a specimen of this aberration on the downs above Ventnor on 4th August 1973. The specimen is female and unfortunately damaged, and still more unfortunately it had already disposed of all its eggs. It is interesting that in the same area, E. Cornell captured a specimen of ab. *albidus* in 1920 and J. Lobb a specimen of ab. *minckii* in 1961.—T. D. FEARNEHOUGH, 26 Green Lane, Shanklin.